Pushing the limits of gravity field recovery from high-low satellite-to-satellite tracking – a combination of 10 years of data of the satellite pseudo-constellation CHAMP, GRACE and GOCE

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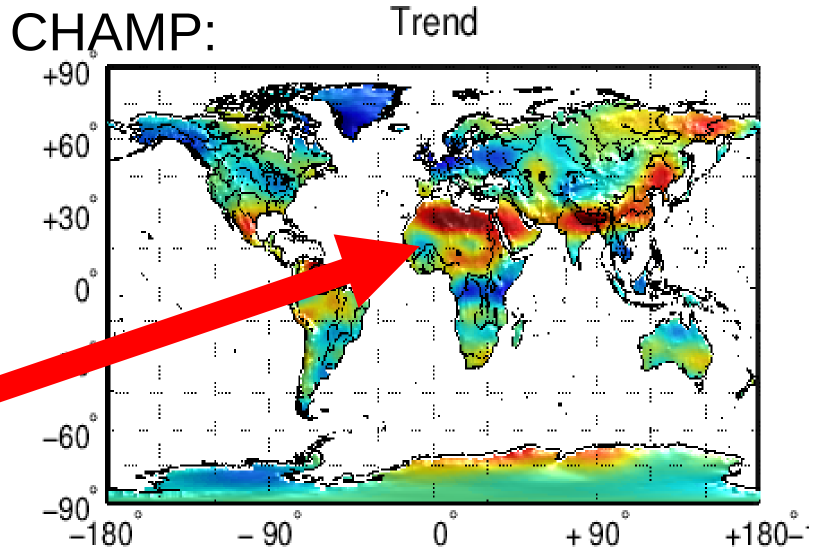
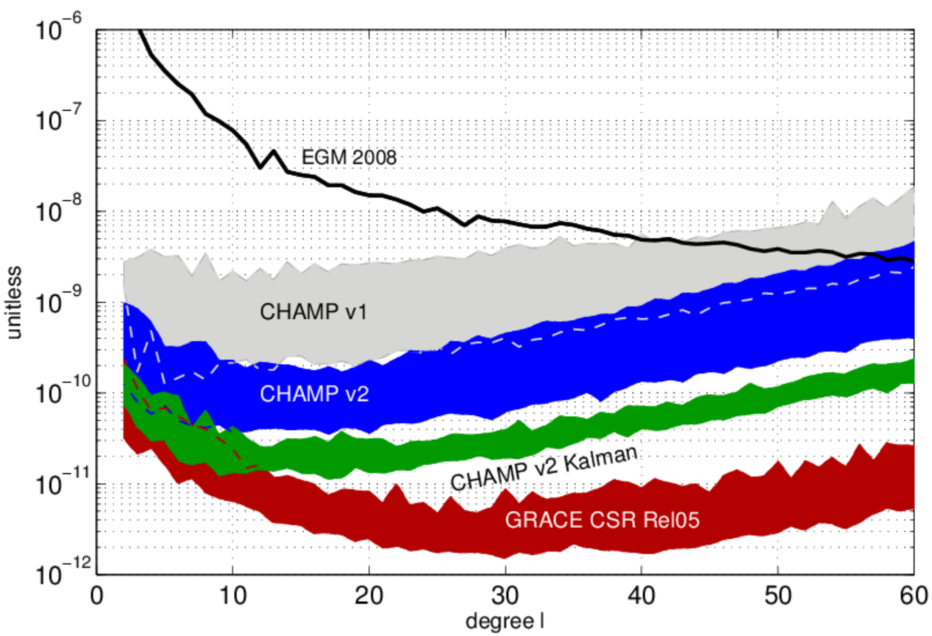
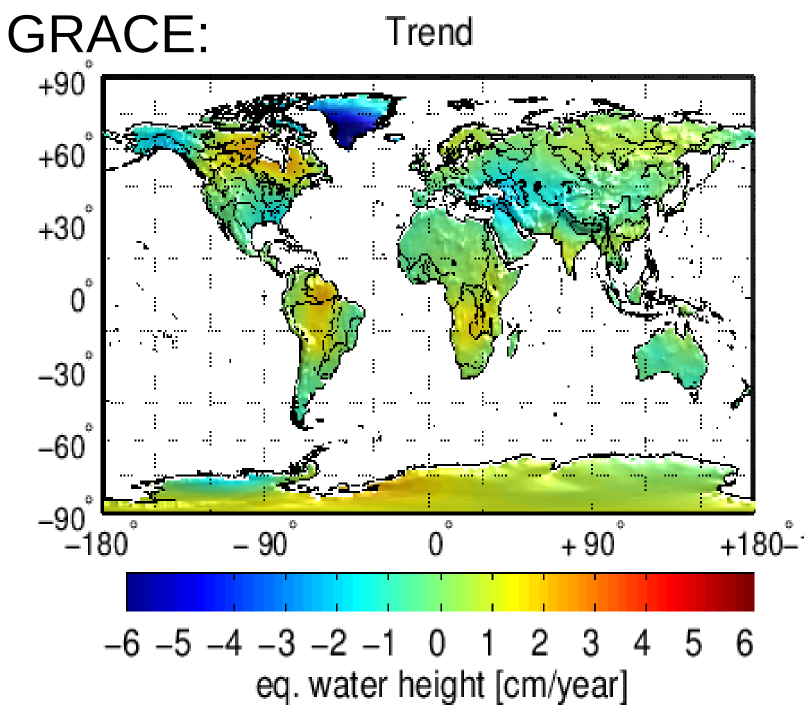
Recall van Dam et al. EGU 2013

- Long wavelength features can be recovered from CHAMP/hl-SST, e.g. the trend in Greenland
- Strong spatial error pattern, e,g. in Africa and Asia







COMBINING CHAMP, GRACE A/B AND GOCE

Data availability for period 2003 to 2012

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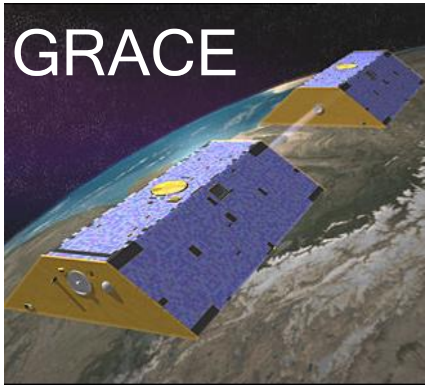

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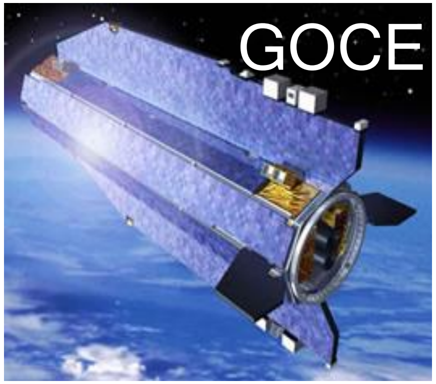

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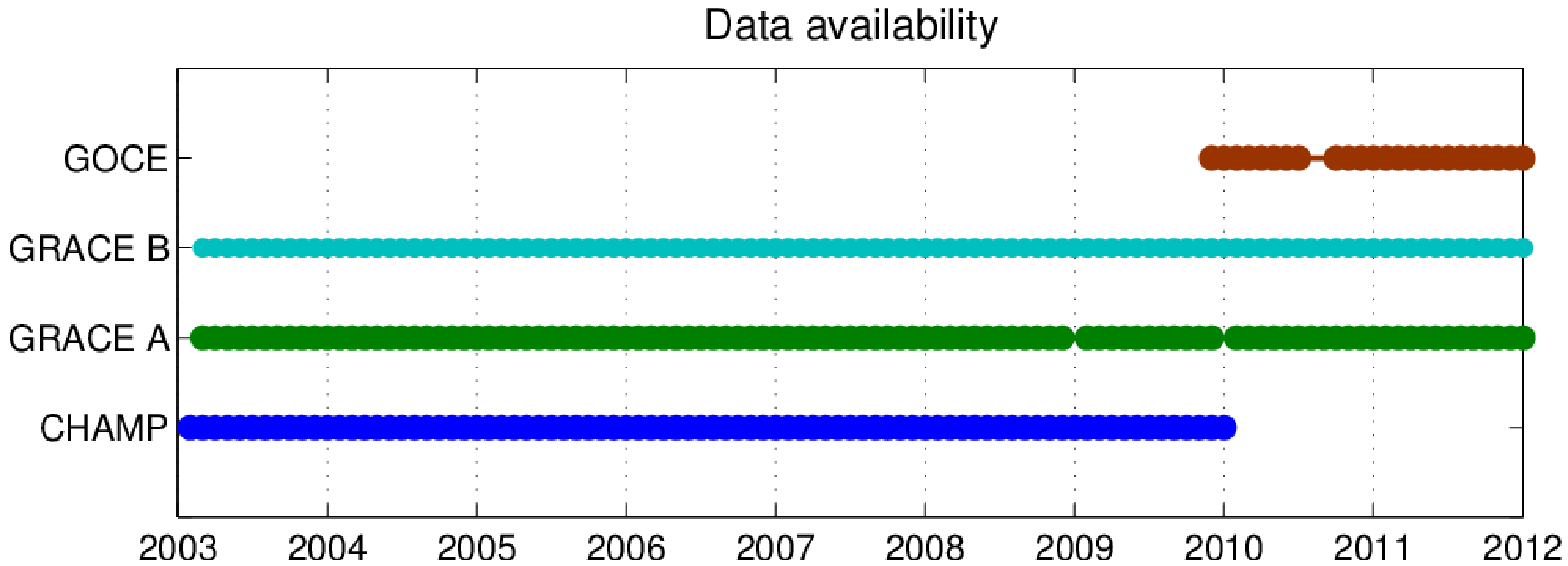

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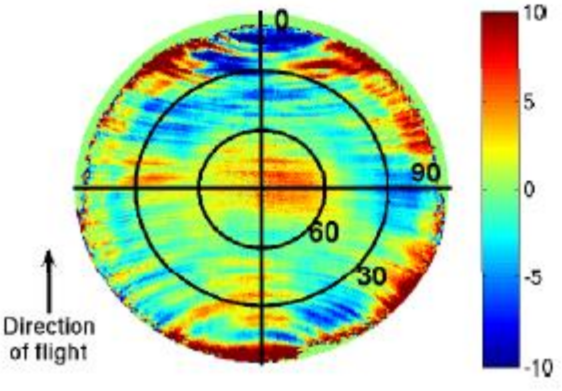
Data processing

GPS positions for CHAMP:

- Prange 2010
- 10 s sampling
- empirical absolute antenna phase center model



Prange 2010

GPS positions for GRACE A/B and GOCE:

- Zehentner et al. 2014 (subsequent talk)
- 10 s sampling
- direct use of code and phase observations
- empirical absolute antenna phase center model

Approach:

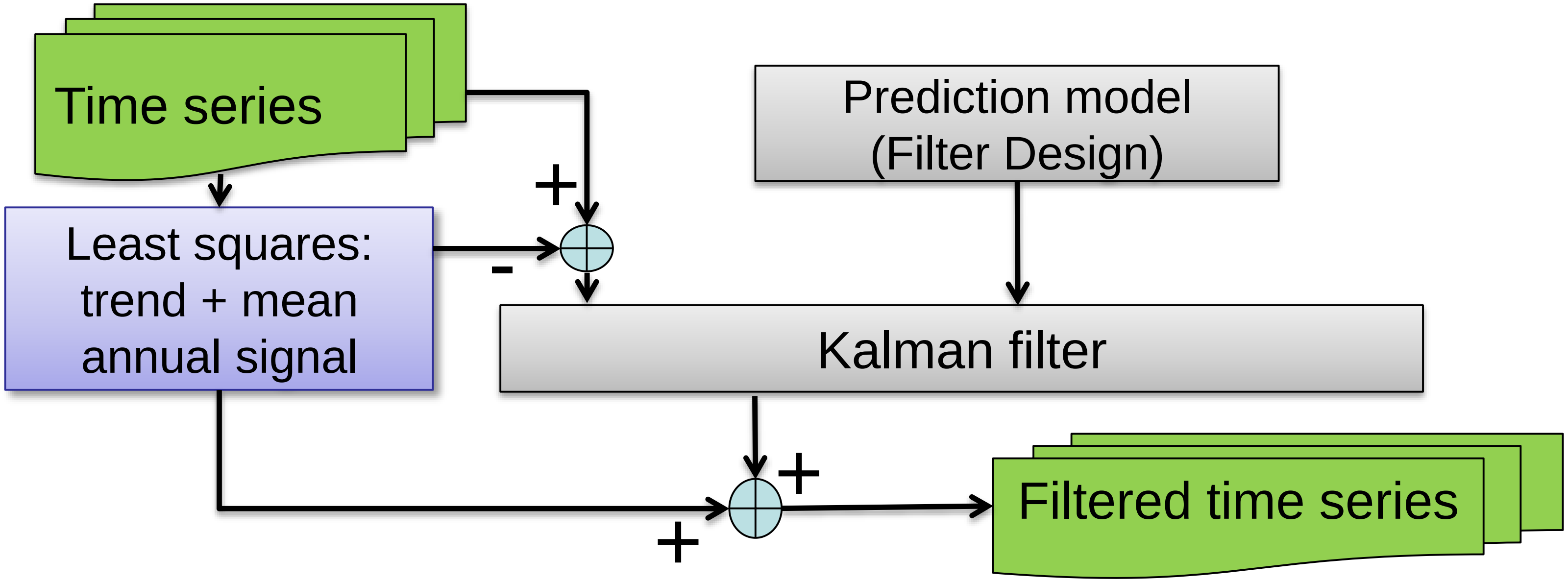
- acceleration approach
- no accelerometer data used
- no regularization and no *a priori* model / information

Result: time series of monthly gravity field solutions for each satellite

REFINED KALMAN-FILTER APPROACH

Kalman-Filter

- formerly using the approach of Davis et al. 2012
- changing to Kurtenbach et al. (2009)
- advantage: the process noise is implicitly defined
- processing scheme:

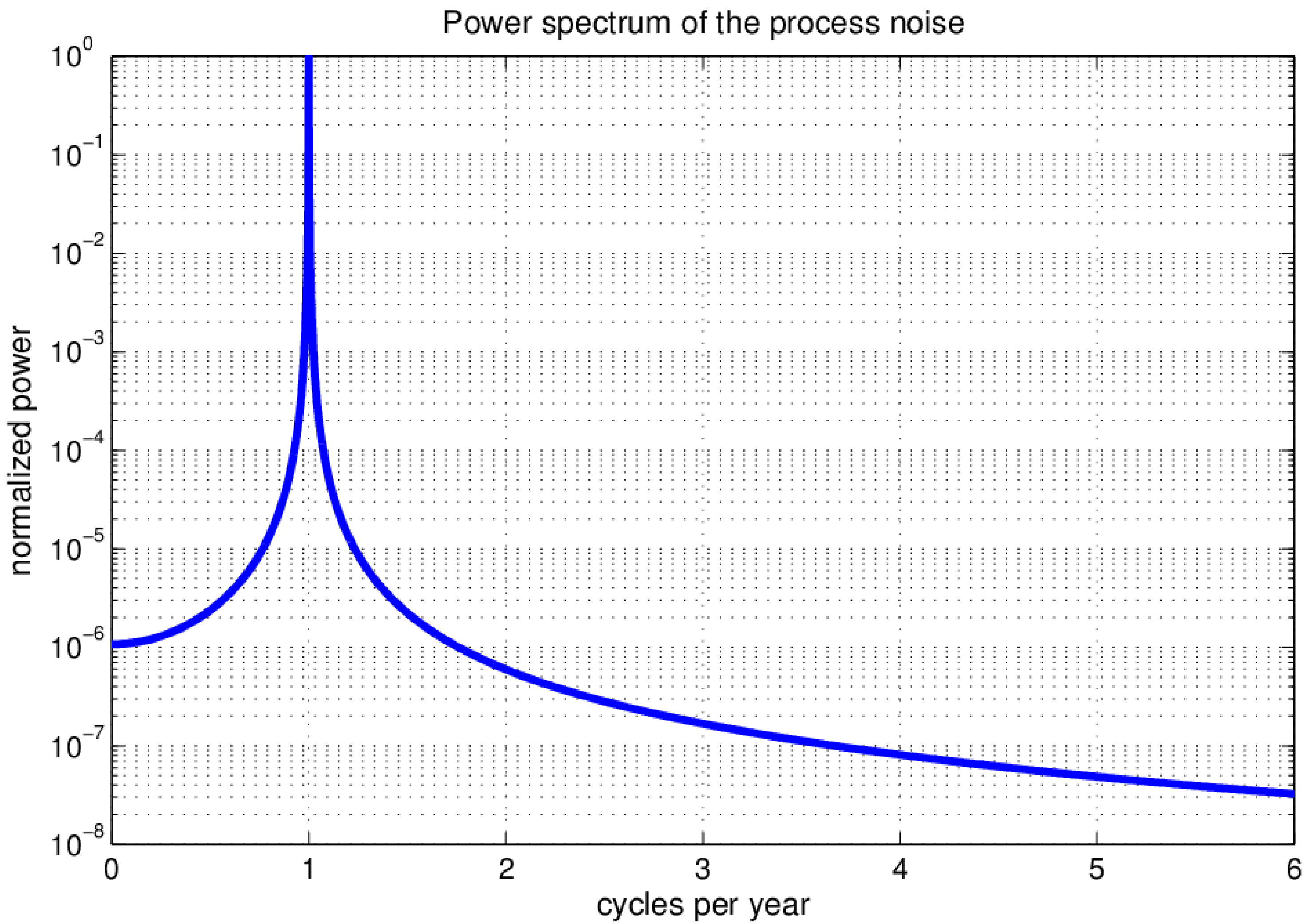


Kalman-Filter: prediction model

- Kalman-Filter: concept of least-squares prediction
  - assuming a stochastic process
  - description by auto- and cross-correlation functions

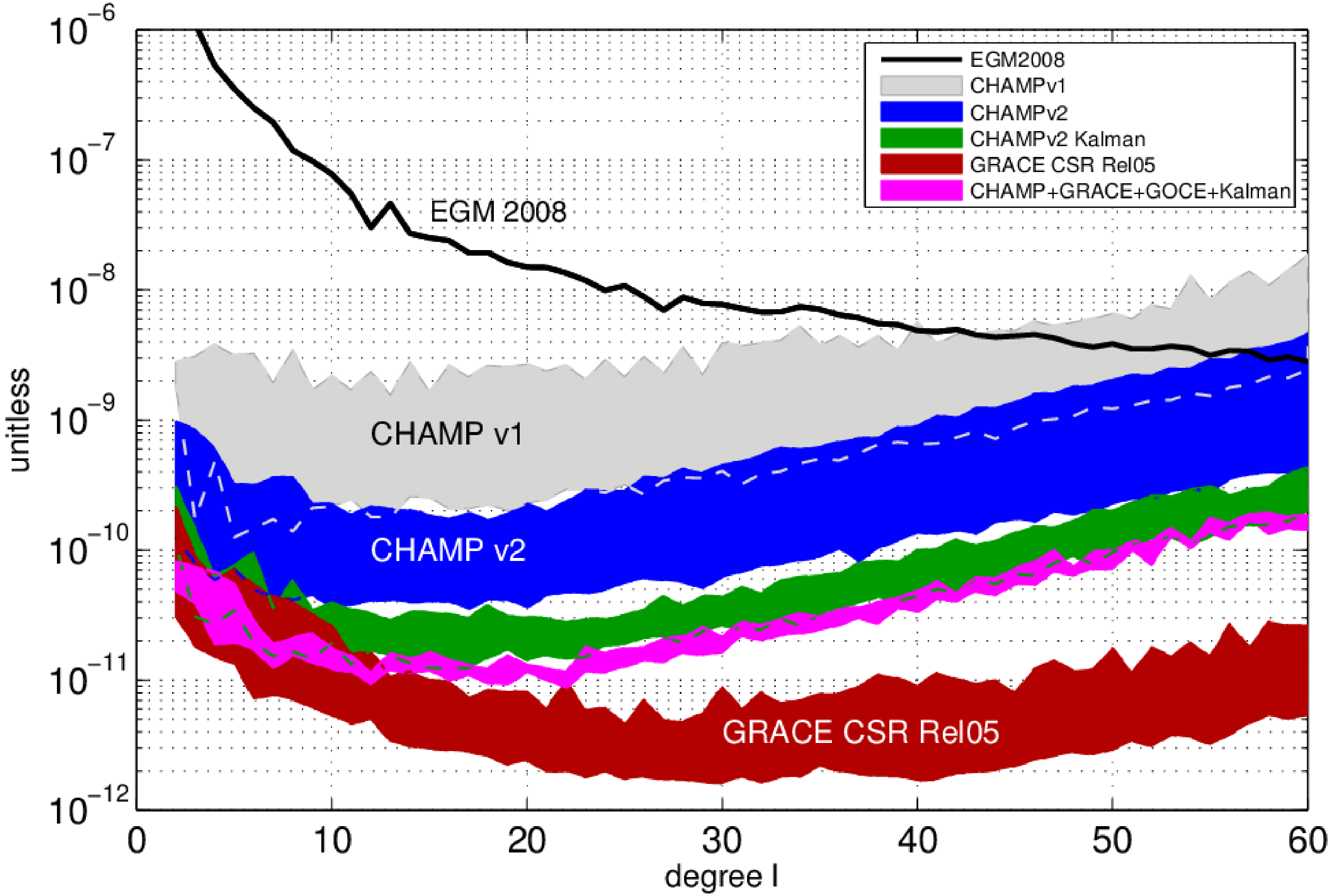
  → prediction model
- in Kurtenbach et al. (2009) correlation functions empirically derived from hydrological models
- Here: no usage of a priori information
- Instead: filter design can be converted to a correlation function
- Filter: only variations around the annual signal

Kalman-Filter: prediction model



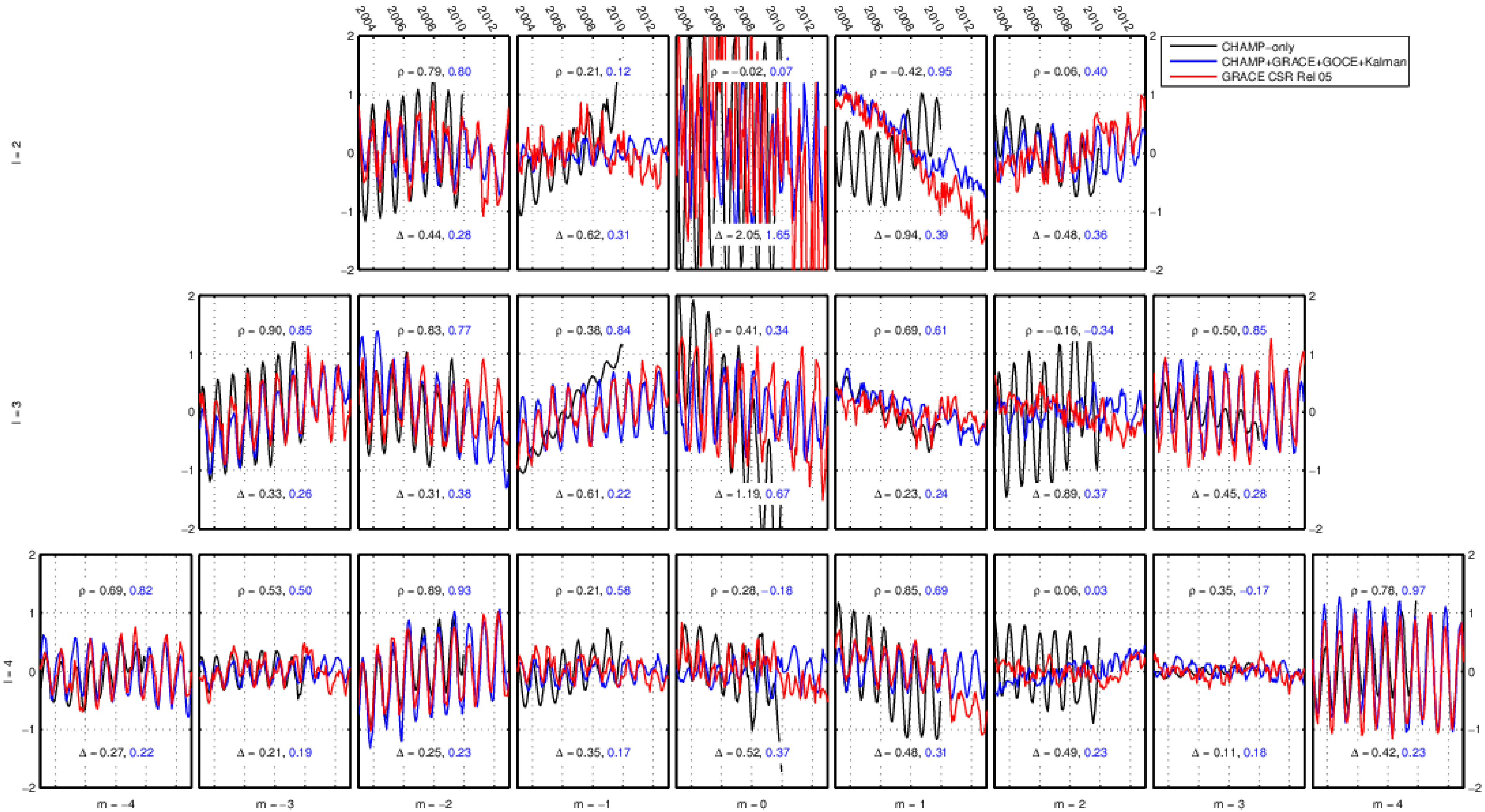
RESULTS

Degree RMS

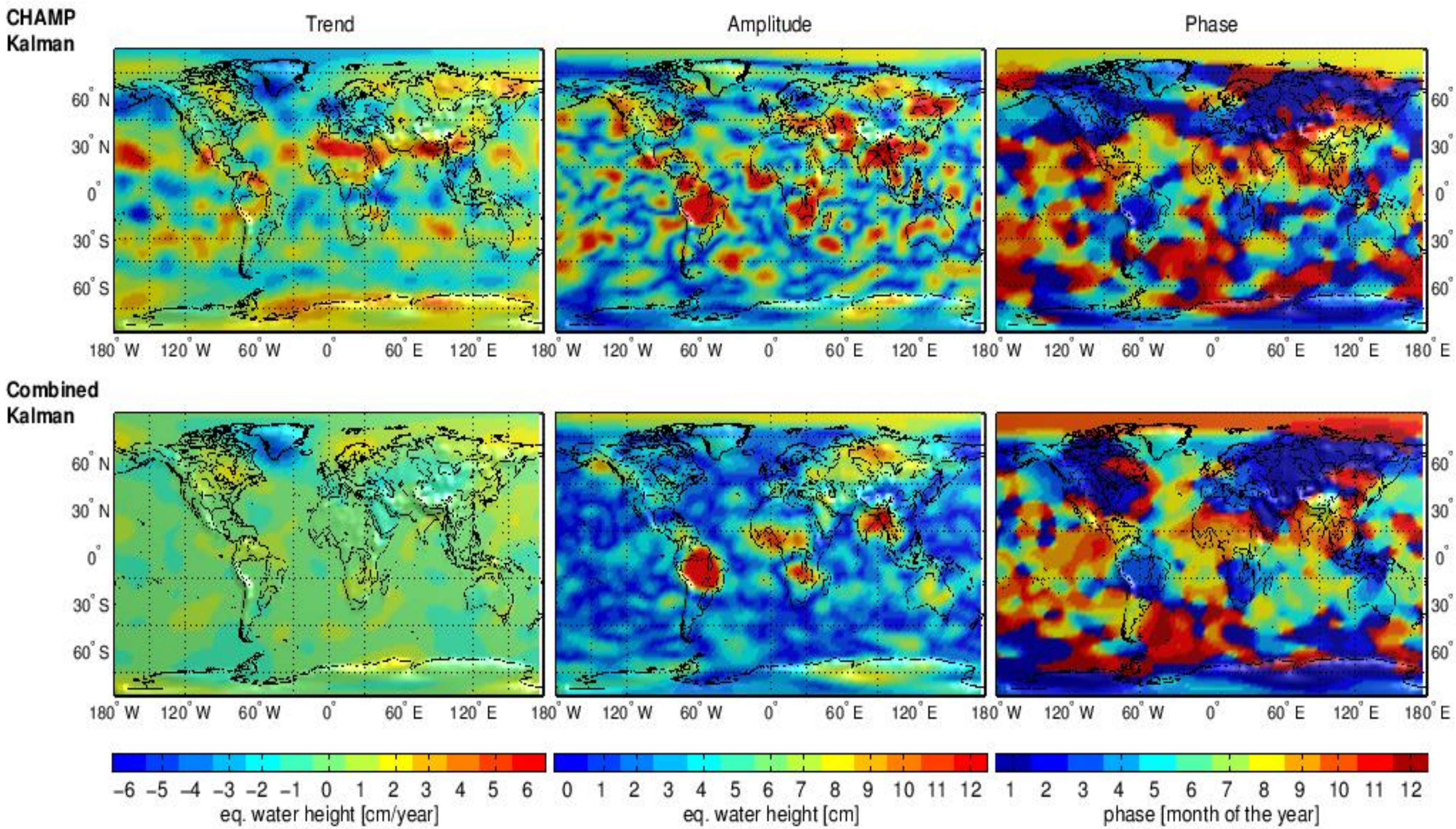


EGM2008
CHAMPv1
CHAMPv2
CHAMPv2 Kalman
GRACE CSR Rel05
CHAMP+GRACE+GOCE+Kalman
EGM 2008
CHAMP v1
CHAMP v2
GRACE CSR Rel05
unitless
degree l

Time series of coefficients



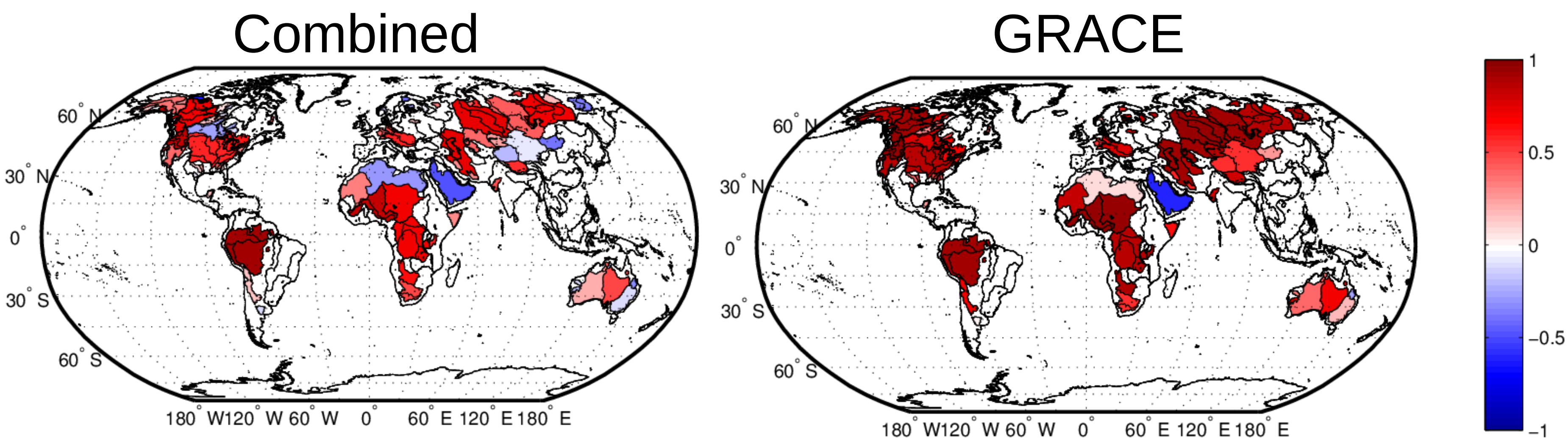
Spatial pattern



VALIDATION AND APPLICATIONS

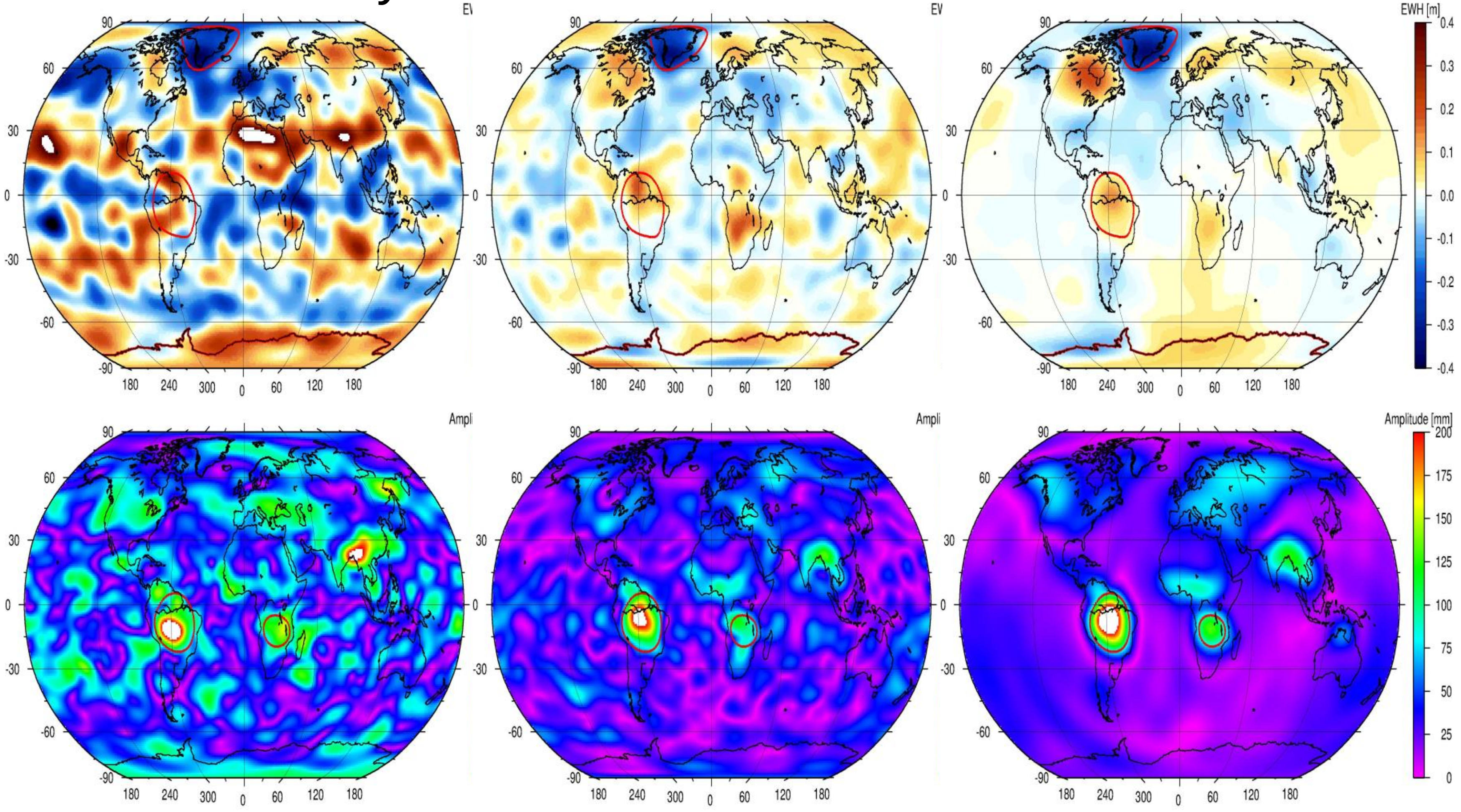
Comparison with hydro-meteorological data

- Comparison with the difference of vertical integrated moisture flux divergences (ERA-INTERIM) and river discharge (GPCC)



Mass trend estimates

CHAMP-only | Combined | GRACE



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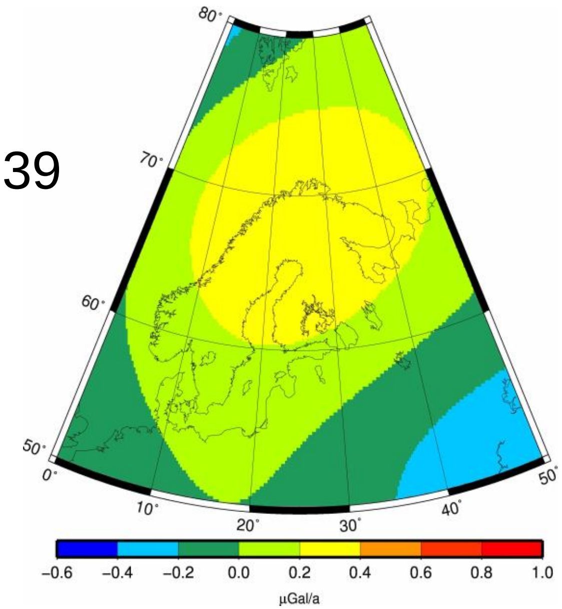
Mass trend estimates

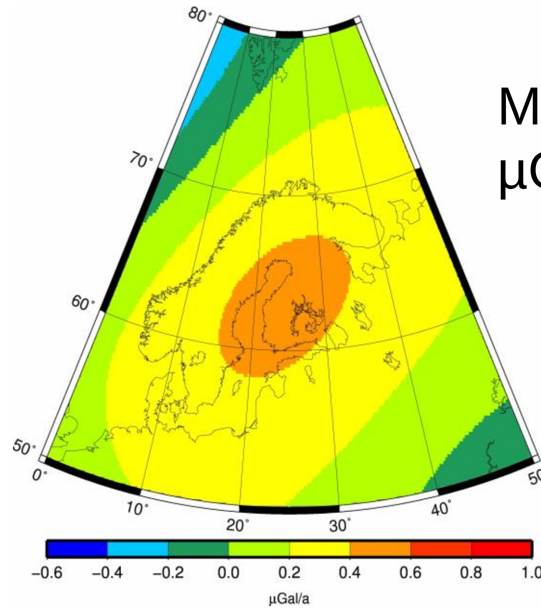
Area	Filter radius	GRACE GT/yr	CHAMP-only GT/yr	Δ to GRACE in %	Combined GT/yr	Δ to GRACE in %
Greenland	1000 km	-239 ± 9	-261 ± 8	7	-208 ± 8	13
	750 km	-238 ± 7	-255 ± 7	9	-218 ± 7	8
Amazon	1000 km	90 ± 18	120 ± 9	33	95 ± 11	6
	750 km	92 ± 17	128 ± 9	39	96 ± 10	4
Antarctica	1000 km	52 ± 16	250 ± 21	481	42 ± 20	19
	750 km	50 ± 14	247 ± 20	494	39 ± 19	22

GIA

Combined hl-SST | GRACE GFZ Rel05

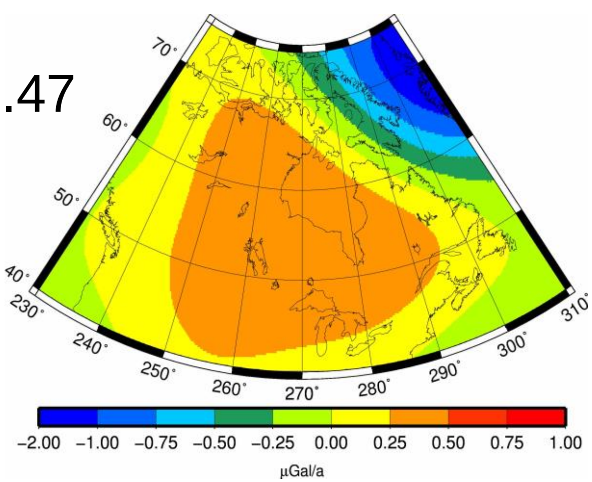
Maximum = 0.39 µGal/a

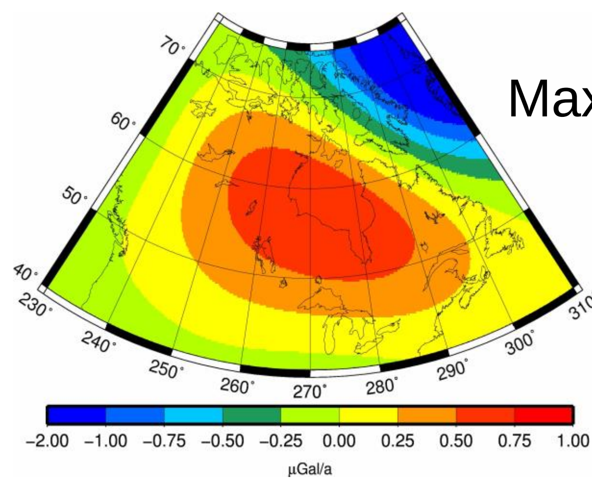




Maximum = 0.44 µGal/a

Maximum = 0.47 µGal/a





Maximum = 0.73 µGal/a

Conclusion:

- Combination yields improved time-variable estimates from hl-SST
- Results agree well with GRACE, hydro-meterological data and loading from GNSS (not shown here).
- Spatial resolution improves from approximately degree 8 to 13.
- Mass estimates differ at most 22% to GRACE estimates.
- GIA estimates show first promising results but remain difficult.